Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L25	2	(spin adj coating) and dispenser and (pressure adj sensor) and (dispense adj line)	US-PGPUB; USPAT	OR	ON	2005/08/11 16:08
L26	26	(spin adj coat) and (pressure adj sensor)	US-PGPUB; USPAT	OR	ON	2005/08/11 16:09
L27	436	(spin adj coat$3) and (pressure adj sensor)	US-PGPUB; USPAT	OR	ON	2005/08/11 16:09
L28	353	(spin adj (coat or coating)) and (pressure adj sensor)	US-PGPUB; USPAT	OR	ON	2005/08/11 16:16
L29	271	28 and line	US-PGPUB; USPAT	OR	ON	2005/08/11 16:10
L30	151	29 and @ad<"20021015"	US-PGPUB; USPAT	OR	ON	2005/08/11 16:11
L31	18	30 and dispenser	US-PGPUB; USPAT	OR	ON	2005/08/11 16:16
L32	10	(spin adj (coat or coating)) and (pressure adj sensor)	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/08/11 16:17
L33	2	32 and dispenser	USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/08/11 16:16

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2692	(spin adj coating) and ((rotate or turntable or rotating) with (substrate or wafer))	US-PGPUB; USPAT	OR	ON	2005/08/24 10:24
L2	234	1 and dispenser	US-PGPUB; USPAT	OR	ON	2005/08/24 10:24
L3	171	2 and @ad<"20021015"	US-PGPUB; USPAT	OR	ON	2005/08/24 10:25

US-PAT-NO: 5358740

DOCUMENT-IDENTIFIER: US 5358740 A

TITLE: Method for low pressure **spin coating** and low pressure **spin coating** apparatus

---------- KWIC ---------

Abstract Text - ABTX (1):

An apparatus and method is provided for **spin coating** films on a surface. The apparatus includes a chamber capable of being closed to the atmosphere, a spinnable member within the chamber capable of supporting the surface and a pump capable of reducing the pressure within the chamber. The method includes depositing a liquid on the surface, reducing the pressure in the vicinity of the surface and spinning the surface.

TITLE - TI (1):

Method for low pressure **spin coating** and low pressure **spin coating** apparatus

Brief Summary Text - BSTX (2):

This invention relates to a **spin coating** apparatus and method and, more particularly, to an apparatus and method for forming a substantially uniform film on a spinning surface.

Brief Summary Text - BSTX (3):

Spin coating is a well known method for forming thin films on a surface. For example, **spin coating** is used in manufacturing semiconductor integrated circuits because one step in semiconductor photolithography processing involves coating thin photoresist films on a semiconductor wafer. **Spin coating** may also be used in other semiconductor manufacturing steps including forming polyimide and silicon dioxide films. **Spin coating** is also used for forming films in other applications including magnetic disks, lens coatings, reflectors, liquid crystal displays and screens. **Spin coating** is well adapted to achieve a film of fairly uniform thickness across a surface.

Brief Summary Text - BSTX (4):

Conventional **spin coating** involves depositing a liquid on a surface which is spinning about an axis. A typical **spin coating** apparatus and method is shown

in FIG. 1. Referring to FIG. 1, a spin coater 10 is shown specifically adapted for applications in semiconductor manufacturing. Surface 12, which may be a semiconductor wafer, is placed on a spinning member 14, for example a semiconductor wafer chuck, which spins about an axis perpendicular to surface 12. Spinning member 14 is contained within a partially open chamber 16. A liquid is deposited onto the surface by a nozzle that is either stationary above the surface or that follows a predetermined path above the surface. During the liquid deposition the surface may or may not be spinning. Typically after the deposition is completed, the spin rate is rapidly increased to a final spin speed. The time duration for the spinning will vary depending on the specific desired results. After spinning, only a thin film is left on the surface. The pressure within the chamber 16 and across the surface is substantially atmospheric in view of the top opening to the chamber and the typical role of exhaust.

Brief Summary Text - BSTX (5):
A **spin coating** liquid is often composed of a nonvolatile material (i.e., a material with a low evaporation rate) dissolved or dispersed in a volatile medium, (i.e., a material with a higher evaporation rate). After the liquid is deposited, centrifugal force causes much of the liquid to flow off the surface. Simultaneously, the volatile medium evaporates. Due to both the centrifugal force and the evaporation, the liquid is converted to a substantially nonliquid thin film comprising the nonvolatile material. The effects of both the centrifugally driven flow of the liquid and the evaporation of the volatile medium from the liquid determine the thickness profile of the final film.

Brief Summary Text - BSTX (6):
An exemplary thickness contour uniformity map obtained using a conventional spin coater 10 is shown in FIG. 2. More specifically, FIG. 2 displays the uniformity of a photoresist film on a six inch diameter semiconductor wafer 22. Liquid photoresist is applied to the surface of the wafer and, after spinning, forms the relatively dry and nonvolatile (as compared to the liquid) photoresist film used for photolithography processing. Typical liquid photoresist comprises nonvolatile materials including a polymer resin (such as novolac) and a photo active agent (such as naptho quinone diazide) dissolved or otherwise dispersed within a volatile solvent such as ethyl lactate or one-methoxy-two-propanol acetate. In this dissolved or dispersed form, a photoresist is frequently referred to as a liquid photoresist. Examples of available liquid photoresists include EL-215.5AN available from Dynachem and OCG-895.I available from OCG. The photoresist film in FIG. 2 was formed by spinning a liquid photoresist on a wafer at 2000 rpm under an exhaust flow of 100 lpm. The mean film thickness, indicated by heavy contour **line** 24, is

approximately 16,731 angstroms and each contour interval is approximately 5 angstroms. The substantial nonuniformity of the film shown in FIG. 2 hinders the development of advanced semiconductor manufacturing technologies.

Brief Summary Text - BSTX (9):
In addition to the process variables known to those skilled in the art, various apparatus modifications have been used to optimize **spin coating** film uniformity. For example in U.S. Pat. No. 5,070,813 to Sakai et al. the exhaust flow rate for a coating apparatus may be changed during the coating process in order allegedly to optimize the coating operation. The exhaust rate is monitored by an exhaust rate detection system. The flow rate detection system operates, in part, on the principle that a gas flow will inherently result in a slight pressure drop. The apparatus is open to the atmosphere so the exhaust flow will inherently cause a slight pressure reduction below atmospheric pressure. However, such slight pressure reductions still result in a nonlaminar and turbulent gas flow across the surface and thus the nonuniform evaporation effects caused by the gas flow above the wafer are not addressed.

Brief Summary Text - BSTX (12):
One **spin coating** apparatus for suppressing turbulent air flow above a spinning surface is described in U.S. Pat. No. 5,069,156 to Suzuki. In this apparatus a spinning wall surrounds the spinning surface in order to modify the air flow above the surface. The spinning wall allegedly slows the air speed relative to the spinning surface by directing the air in the same rotating direction as the surface. The modified air flow is said to reduce the aerodynamic forces of the air on the liquid and thus improve the final film thickness uniformity. However, this apparatus still results in turbulent air flow and does not address thickness nonuniformities which result from nonuniform evaporation rates caused by turbulent air flow.

Brief Summary Text - BSTX (17):
The apparatus of the present invention which is used to form a film on a surface includes a chamber, a support member placed within the chamber and adapted to spin a surface about an axis, and a pump for reducing a pressure in the vicinity of the support member in order to maintain a Reynolds number sufficiently low to form a film of substantially uniform thickness. The chamber may be closed to the atmosphere, and may include a liquid **dispenser** which dispenses the liquid on the surface. The apparatus may further include at least one gas inlet which is adapted to direct gas into the chamber, and at least one gas outlet which is adapted to remove gas from the chamber. As with the method of the present invention, the liquid may comprise a substantially non-volatile material dispersed in a substantially volatile medium, such as,

for example, a liquid photoresist.

Detailed Description Text - DETX (7):
For example, the prior art film coating shown in FIG. 2 was coated with the prior art apparatus shown in FIG. 1 at a spin speed of 2000 rpm in air at substantially atmospheric pressure and with an exhaust flow rate of 100 lpm. If the transition radius for the first flow instability, radius 30 in FIG. 3, is taken to correspond to the mean film thickness contour **line** 24 in FIG. 2, then the first flow transition occurs at a Reynolds number of approximately 0.5.times.10.sup.5. It is possible that the added exhaust flow from exhaust 18 lowers the stability limit slightly from the predictions of experiments without this flow.

Detailed Description Text - DETX (8):
The present invention involves **spin coating** under a reduced pressure to eliminate the gas flow instability from occurring adjacent to the spinning surface. Thus, Equation 2 can be rewritten to show the pressure dependency of the Reynolds number. The kinetic viscosity of air, v, is related to the viscosity of air, .mu., and density of air, .rho., as shown in Equation 3. ##EQU3## Because at the pressures of interest here the viscosity of air is nearly independent of pressure and the ideal gas law can be taken as a good approximation for the dependence of density on pressure, the density and pressure are substantially related as shown in Equation 4, ##EQU4## where P is the air pressure, M is the air molecular weight, T is the air temperature and R.sub.g is the ideal gas constant. Thus, the local Reynolds number of the gas flow will scale linearly with the pressure of the overlying gas, as shown in Equation 5. ##EQU5## It should be recognized that gasses other than air may be used and will show a similar pressure and flow instability dependency.

Detailed Description Text - DETX (12):
It should be noted that the above theory was based on the gas flow created over a substantially circular spinning surface. However, the principle of reducing the pressure to reduce gas flow disturbances and to decrease nonuniformities in the mass transfer coefficient may also be applied to more complicated gas flows over noncircular surfaces. Thus, the present invention may also be used for **spin coating** substantially noncircular surfaces.

Detailed Description Text - DETX (14):
In one embodiment, the invention comprises a system, as shown in FIG. 4, for forming a thin, uniformly thick film on a surface member by **spin coating**. The invention, more particularly, comprises a spinnable support member 40 which is capable of supporting a flat, laterally disposed specimen or other surface 41,

and which is capable of spinning about an axis 42 substantially perpendicular to a plane of the surface. The support member is mounted within a sealable chamber 43. Chamber 43 may have at least one gate valve 44 or other closable mechanism through which the surface may pass. Chamber 43 is designed to create a gas flow pattern 54 such that gas flows in a generally axisymmetrical pattern outward from spin axis 42 across surface 41. Chamber 43 has a gas flow system comprising spinning surface 41, chamber sidewalls 50, one or more gas inlets 45, and one or more gas outlets 46. Gas inlets 45 and gas outlets 46 are positioned such that gas entering the chamber flows outward across surface 41 and then exits through the outlets.

Detailed Description Text - DETX (15):
Pressure within the chamber is reduced by a vacuum pump 47, blower or the like which is connected to outlets 46, and which is capable of reducing the pressure within the chamber to a value less than atmospheric pressure. It is recognized that even an exhaust flow of gas in an unsealed chamber over a surface as generated by the exhaust 18 in the prior art apparatus shown in FIG. 1 will inherently cause a slight pressure reduction below atmospheric pressure. However, modeling shows that the prior art pressure in the vicinity of the surface is greater than 0.99 atmosphere for conventional exhaust flows of 100-800 lpm. The pressure reductions desired by the present invention, however, are greater than this slight effect. Thus, for air it is desired that the pressure within the chamber be less than about 0.5 atmosphere and preferably less than about 0.2 atmosphere. Pressures within the range between about 0.01 and 0.3 atmosphere are generally contemplated, and especially between about 0.05 and 0.2 atmosphere. The pressure within chamber 43 may by monitored and controlled by a **pressure sensor** 48 that is connected to a pressure control valve 49.

Detailed Description Text - DETX (19):
Liquid **dispenser** 52, for example a nozzle or the like, may be used to dispense liquid photoresist on the wafer. This may be done by discharging the liquid photoresist in a variety of ways. For example, the nozzle may stay stationary, follow a predetermined pattern across the wafer, emit a multiple stream spray, or emit a single stream. The present invention is not dependent on any specific nozzle means.

Claims Text - CLTX (50):
26. The apparatus of claim 25, further comprising a liquid **dispenser** adapted to dispense a liquid on the surface.

Other Reference Publication - OREF (1):

Bornside et al., "**Spin coating**: One-dimensional model," Journal of Applied Physics, 66(11):5185-5193, Dec. 1, 1989.

Other Reference Publication - OREF (2):
Bornside et al., "On the Modeling of **Spin Coating**," Journal of Imaging Technology, vol. 13, 4:122-130, Aug. 1987.

Other Reference Publication - OREF (3):
Bornside et al., "**Spin Coating** of a PMMA/Chlorobenzene Solution," Journal of the Electrochemical Society, vol. 138, 1:317-320, Jan. 1991.

Other Reference Publication - OREF (4):
Chen, "Investigation of the Solvent-Evaporation Effect on **Spin Coating** of Thin Films," Polymer Engineering and Science, vol. 23, 7:399-403, May 1983.

Other Reference Publication - OREF (12):
Flack et al., "A Mathematical Model for **Spin Coating** of Polymer Resists," Journal of Applied Physics, vol. 56, 4:1199-1206, Aug. 15, 1984.

Other Reference Publication - OREF (17):
Lai et al., "An Investigation of **Spin Coating** of Electron Resists," Polymer Engineering and Science, vol. 19, 15:1117-1121, Nov. 1979.

Other Reference Publication - OREF (26):
Sukanek, "**Spin Coating**," Journal of Imaging Technology, vol. 11, 4:184-190, Aug. 1985.